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The effect of motivation and positive affect on ego depletion: Replenishment versus release mechanism

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In this study, 2 experiments were conducted to investigate whether motivation and positive affect can alleviate ego depletion and to elucidate their possible mechanisms. In Experiment 1, a crossing-out-letter task was adapted to reach an ego depletion state for Chinese participants. Participants were then randomly assigned to the extrinsic motivation group, the positive affect group or the depletion control group. After the experimental treatment, a dumbbell task was used to measure participants' remaining self-regulatory resources. The results showed that participants in the motivation and positive affect groups performed better on the dumbbell task than participants in the depletion control group. Experiment 2 was similar to Experiment 1 except that participants were asked to perform an additional unexpected dumbbell task after a neutral video following the above procedure. The results of Experiment 1 were replicated; however, participants' performance on the additional dumbbell task differed. The positive affect group performed better than the depletion control group, indicating an increase in self-regulatory resources and thus supporting the replenishment effect of positive affect. No significant difference was found between the motivation group and the depletion control group.

Keywords: Self-regulation; Motivation; Positive affect; Ego depletion; Mechanism.

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SELF-REGULATION AND EGO DEPLETION

Despite the importance of self-regulation in daily life (e.g. Baumeister & Vohs, 2007; Tangney, Baumeister, & Boone, 2004), it all too often fails. Attempting to understand why it fails has become a major endeavour in psychology today (Baumeister, 2002). One particular model of self-regulation failure suggests that self-regulation draws upon a limited energy resource that declines with use (e.g. Baumeister, Heatherton, & Tice, 1994). Just as a muscle tires from exertion, when individuals engage in self-regulation tasks, resources are consumed and strength will be diminished (Baumeister, Vohs, & Tice, 2007; Baumeister et al., 1994).

This model suggests that with insufficient available strength, individuals may perform poorly on subsequent tasks that require self-regulation. Baumeister et al. refer to this state of diminished resources following the exertion of self-regulation as ego depletion (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Baumeister et al., 2007). A number of negative outcomes in the areas of smoking cessation, alcohol addiction, drug abuse, overeating, impulsive buying, crime, dropout, gambling and relationship problems have been associated with ego depletion (e.g. Baumeister, 2002; Baumeister & Heatherton, 1996; Muraven, Collins, Shiffman, & Paty, 2005; Vohs & Faber, 2007). In summary, ego depletion can introduce suffering into many aspects of life (for a review, see Muraven & Baumeister, 2000).

ALLEVIATING EGO DEPLETION

Because ego depletion is associated with many negative outcomes, researchers have attempted to alleviate its effects. Previous studies have identified ways to address these effects, including consuming a glucose drink (Gailliot et al., 2007), increasing self-awareness (Alberts, Martijn, & de Vries, 2011), improving self-affirmation (Schmeichel & Vohs, 2009), manipulating motivation (Muraven & Slessareva, 2003) and inducing positive affect (Tice, Baumeister, Shmueli, & Muraven, 2007). This study focuses on manipulating motivation and inducing positive affect.

Motivation is an inner incentive that compels individuals to attain certain goals and sustain goal-directed behaviours. Researchers have demonstrated that motivation can lead to better performance on self-regulation activities, such as pain tolerance tasks

(Verhoeven et al., 2010) and decision-making activities (Moller, Deci, & Ryan, 2006), which suggests that motivation may work to counteract ego depletion. Muraven and Slessareva (2003) directly explored the relationship between motivation and ego depletion and found that ego-depleted individuals with high motivation, whether intrinsic or extrinsic, performed better on subsequent tests of self-regulation.

In addition to motivation, several studies suggest that positive affect can also alleviate ego depletion (i.e. Tice et al., 2007). Positive affect is a momentary and beneficial hedonic feeling evoked by meaningful events (Fredrickson, 1998). Positive affect can help individuals perform better on decision-making tasks, problem-solving tasks and information processing (e.g. Isen & Means, 1983), all of which require self-regulatory resources (i.e. Vohs et al., 2014). More direct evidence can be found in the work of Tice et al. (2007). They found that participants in the positive affect group consistently performed better on self-regulation tasks than neutral or negative affect group participants in four experiments. In summary, these studies demonstrate that positive affect can alleviate the ego-depletion effect.

Despite the fact that both motivation and positive affect have been found to be effective in alleviating the ego-depletion effect, they may work in different ways. For example, it is unknown if motivation and positive affect work to release reserved resources, or to increase overall levels of self-regulatory resources.

We speculated that motivation might help alleviate ego depletion by allocating more reserved self-regulatory resources to the current task. From the perspective of resource allocation, when individuals engage in several tasks that require the same resources, they allocate different amounts of the limited resource to different tasks in an optimal way (i.e. Shaw & Shaw, 1977). Considering that self-regulatory resources are a type of psychological resource, the allocation mechanism may also apply and this idea has been supported by empirical evidence. Muraven, Shmueli, and Burkley (2006) found that ego-depleted individuals who anticipated a subsequent self-regulation task conserved resources for future use and thus performed more poorly on the current task but better on the future task than those who did not expect to exert self-regulatory resources in the future (Muraven et al., 2006). Accordingly, Muraven et al. proposed the conservation model, suggesting that depleted individuals tend to allocate more

resources for future tasks and thus fewer resources for the current one. On the basis of the theories and empirical evidence mentioned above, we hypothesised that if individuals are rewarded for performing well on the current task, they are less likely to reserve resources for future use and are more inclined to devote resources to the current one. Thereby, motivation may effectively help them to overcome self-regulation failure on the current task.

As noted above, positive affect can also serve to enhance self-regulation and counter ego depletion but may function in a different way, through a process which we term the replenishment mechanism. According to the Broaden-and-Build Theory (Fredrickson, 1998), positive affect has a complementary effect that can broaden one's momentary thought-action repertoire and build personal resources ranging from physical and social resources to intellectual and psychological resources (Fredrickson, 1998). Some empirical studies provide preliminary evidence that positive affect could build psychological resources (e.g. Tugade & Fredrickson, 2004). Take psychological resilience as an example. As an enduring psychological resource, resilience helps individuals bounce back from stressful experiences quickly and efficiently (Lazarus, 1993). A previous study found that individuals with higher levels of positive affect before a stressful task were more resilient during the task (Tugade & Fredrickson, 2004). Because self-regulation is also understood as a psychological resource, positive affect may influence self-regulation in a similar way. Just as rest can help tired individuals regain physical energy, positive affect may alleviate ego depletion by rebuilding or replenishing more self-regulatory resources.

PURPOSE

As reviewed above, although both extrinsic motivation and positive affect could alleviate ego depletion, they may work in different ways (e.g. Muraven & Slessareva, 2003; Tice et al., 2007). Understanding their working mechanisms is of great importance to selecting proper ways to alleviate ego depletion in different conditions. For instance, if individuals are going to complete several successive important self-regulation tasks, it would be more appropriate to help them alleviate ego depletion using ways that replenish rather than release self-regulatory resources. Otherwise, their

performance on later tasks would suffer due to lower resource availability. However, no empirical studies have explored their working mechanisms. Therefore, in this study, we took an initial step in exploring how they function in two experiments.

The first experiment was designed to examine whether motivation and positive affect could alleviate ego depletion for Chinese participants as it did in Western culture. We predicted that participants with extrinsic motivation or positive affect would perform better on subsequent self-regulation tasks than participants in the depletion control group. Thus, two hypotheses were proposed:

Hypothesis 1: The motivation group will perform better on subsequent self-regulation tasks than the depletion control group.

Hypothesis 2: The positive affect group will perform better on subsequent self-regulation tasks than the depletion control group.

Based on Experiment 1, Experiment 2 was conducted to further explore the mechanisms of motivation and positive affect in alleviating ego depletion. If depleted individuals were rewarded by performing well on the current task, they may allocate more of their self-regulatory resources to it. Thus, fewer resources would remain and worse performance would be expected on the future task. If positive affect could build or replenish self-regulatory resources, however, participants in the positive affect group should perform better on the current task and perform equal to or better than participants in the depletion control group on the future task. Therefore, we hypothesised the following:

Hypothesis 3: The motivation group will perform better on the current task and worse on the future task than the depletion control group.

Hypothesis 4: The positive affect group will perform better on the current task and equal to or better on the future task than the depletion control group.

EXPERIMENT 1

Method

Participants

Sixty-six students from three large public universities in a metropolitan area in China were recruited and randomly assigned to the depletion control group, the motivation group and the positive affect group. Participants were paid 20 RMB for their participation at the end of the experiment. Three participants were excluded due to a misunderstanding regarding the tasks. Thus, the data for 63 participants are reported here (46 females; $M_{\text{age}} = 21.56 \pm 2.41$; 20 participants were assigned to the motivation group, 21 to the positive affect group and 22 to the depletion control group; all were right handed).

Procedure

Self-regulation performance was measured by persistence time (seconds) on a dumbbell task (Geeraert & Yzerbyt, 2007). First, a baseline test (DB_0) was conducted to measure individual differences in physical strength. Participants were instructed to sit at a table and hold a five-pound dumbbell 15 – 20 cm above the surface of the table with their non-dominant hand as long as possible.

Then, all participants were instructed to complete a crossing-out-letter task to reach an ego-depletion state. This task is adapted from an initial task that has been shown to be effective in previous studies (Baumeister et al., 1998; Tice et al., 2007). Because not all Chinese participants are equally familiar with English vowels and consonants, the English letters were replaced by the Chinese Pinyin.

A pilot study was conducted to validate the adapted manipulation task. In the first session, all participants were instructed to cross out every letter “i” in an article consisting of Chinese Pinyin to establish a habit of marking “i.” The second session almost repeated the first session. Participants in the non-depletion condition finished another article with the same rule. Participants in the depletion condition, however, could not cross out an “i” if the word itself or its adjacent words contained a second tone, such as “cái” (itself) or “sūn jiàn guó” (adjacent). In this condition, participants had to override the habitual response of crossing out “i.” The results showed that the depletion group ($M = 85.50$, $SD = 41.97$) performed worse than the non-depletion group ($M =$

94.90, $SD = 25.50$) on a subsequent self-regulation task, $F(1, 17) = 4.20$, $MSE = 162.31$, $p = .056$, $partial \eta^2 = .20$. The ego-depletion manipulation check showed that there was no significant difference in the perceived difficulty of the tasks between the depletion group ($M = 3.80$, $SD = 2.39$) and the non-depletion group ($M = 2.70$, $SD = 1.49$). Participants in the depletion group ($M = 6.80$, $SD = 2.90$) believed that the latter session was far more difficult than the former one (non-depletion group, $M = 2.50$, $SD = 2.80$), $t(18) = 3.38$, $MSE = 1.27$, $p < .01$, $d = 1.51$. Compared with the non-depletion group ($M = 6.70$, $SD = 2.36$), the depletion group ($M = 4.50$, $SD = 2.12$) thought they had less energy left when finishing the task, $t(18) = -2.19$, $MSE = 1.00$, $p < .05$, $d = 0.98$. The depletion ($M = 3.60$, $SD = 2.55$) and non-depletion groups ($M = 5.30$, $SD = 2.31$) did not differ significantly on preference for the task. Owing to the small sample size and the relatively large effect size, it is reasonable to regard the crossing out “i” task as an effective method among Chinese participants. Unlike in the pilot study, this study asked all participants to complete the depletion condition.

After the depletion task, the participants were asked to complete an 11-point (from 0 to 10) manipulation check measure that assessed the difficulty (two items, e.g. “How difficult was the entire task?”), energy consumed (one item, e.g. “If the baseline of your energy before the task was 10, how much energy remained when you finished it?”), preference for the task (one item, e.g. “How pleasant was the task?”) and the Positive Affect and Negative Affect Schedule (PANAS) scale. The adapted PANAS for Chinese participants is a 5-point, 18-item scale with high validity and reliability to measure one’s current emotion (Qiu, Zhang, & Wang, 2008).

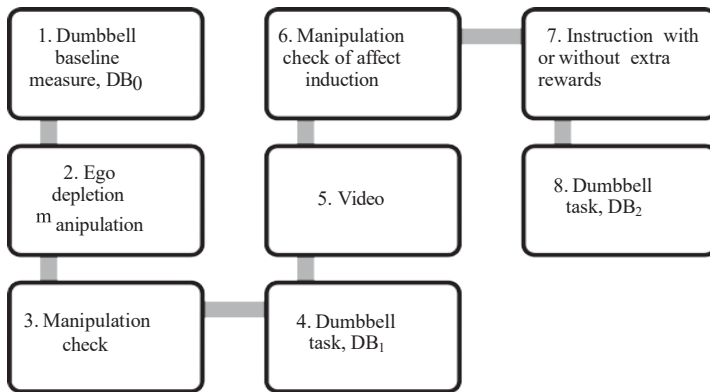


Figure 1. Process of Experiment 1.

Next, a first-time post-test of the dumbbell task (DB₁) was included as a baseline measure of self-regulatory strength after depletion. The instruction was the same as in DB₀. Their persistence time was also recorded.

Then, participants in the positive affect group watched a 337-second comedy video. The comedy video was a combination of clips from “America’s Funniest Home Videos” and a similar Chinese programme that included funny behaviours. A manipulation check of affect induction consisting of two items was used to measure how happy and pleasant participants felt after watching the video (9-point scale; e.g. “How happy are you at present?”). The motivation group and the depletion control group watched a neutral clip of the BBC documentary “Wild China” of the same length, which introduced scenery and wild animals in China, and completed the same manipulation check.

For the motivation group, immediately after the manipulation check, participants were told that they could receive an extra 5 RMB if they could persist for at least 100 seconds in the following dumbbell task, 10 RMB if they could persist for at least 150 seconds and 50 RMB if they could persist for at least 200 seconds. The positive affect group and the depletion control group were not informed of the extra rewards.

After that, all participants completed the second dumbbell task post-test (DB₂). The instructions were the same as those in previous trials of the dumbbell task. The complete process involved in Experiment 1 is shown in Figure 1.

Results and discussion

Baseline test and manipulation checks

The three groups showed no significant difference in baseline physical strength, DB_0 , $F(2, 60) = 1.51$, $MSE = 2430.95$, ns., and self-regulatory resources after depletion, DB_1 , $F(2, 60) = 0.26$, $MSE = 921.31$, ns., nor did the manipulation check of ego depletion or the PANAS show significant differences among the three groups (see Table 1), which suggests that all groups had the same degree of ego depletion and affect state before the manipulation.

TABLE 1
Descriptive statistics of Experiment 1

	<i>Motivation group</i> (<i>M ± SD</i>)	<i>Affect group</i> (<i>M ± SD</i>)	<i>Control group</i> (<i>M ± SD</i>)
Manipulation check			
Perceived difficulty	3.90 ± 2.34	4.00 ± 2.14	4.68 ± 2.50
Difficulty compared	6.25 ± 2.47	7.10 ± 1.41	7.23 ± 2.02
Energy remained	5.05 ± 2.35	5.52 ± 1.97	4.82 ± 2.56
Preference	4.25 ± 2.57	3.57 ± 2.46	3.55 ± 3.04
PANAS	10.65 ± 9.34	8.86 ± 5.30	10.27 ± 9.28
Affect manipulation	11.00 ± 3.15	14.05 ± 2.36	12.09 ± 2.94
DB ₀	113.45 ± 43.51	133.33 ± 61.78	108.45 ± 39.97
DB ₁	88.05 ± 35.10	88.86 ± 27.30	82.68 ± 28.42
DB ₂	98.00 ± 42.28	86.90 ± 28.07	71.27 ± 24.42

Note: In the manipulation check, “Perceived difficulty” means “How difficult was the entire task?” “Difficulty compared” means “Is the latter session more difficult than the former one?” “Energy remained” means “If the baseline of your energy before the task was 10, how much energy remained when you finished it?” and “Preference” means “How pleasant was the task?” DB is the short form of dumbbell. The dumbbell task was measured in seconds. DB₀ stands for the dumbbell task pre-test, DB₁ indicates the first dumbbell task post-test after ego depletion and DB₂ indicates the dumbbell task post-test after manipulation.

The manipulation check of affect revealed that participants who watched the comedy video had more positive affect than those who watched the neutral video, $F(2, 60) = 6.13, p < .01, MSE = 8.01, partial \eta^2 = .17$, and no significant differences were found between the motivation and depletion control groups in the manipulation check. Descriptive statistics are presented in Table 1.

Dependent measure

DB₂ was chosen as the dependent variable. Owing to individual differences in depletion levels seen in the measurements, no functional relationship between DB₀ and DB₁ could be found. Thus, we included both DB₀ and DB₁ as covariates to control irrelevant variances. The results from analysis of covariance (ANCOVA) and the *post-*

hoc test indicated that both the motivation group and the positive affect group performed better on the dumbbell task than the depletion control group after the manipulations, $F(2, 58) = 11.46$, $MSE = 214.15$, $p < .001$, $partial \eta^2 = .28$. The results of each trial of the dumbbell task are shown in Table 1.

The results of the *post-hoc* test showed that motivation and positive affect were two effective methods to alleviate the effect of ego depletion. Therefore, both Hypothesis 1 and Hypothesis 2 were supported. After the manipulation, however, participants in the motivation group performed much better on the dumbbell test than those in the positive affect group. Two explanations can be given for this result. First, it is probable that extrinsic motivation is a better way to alleviate the ego-depletion effect than by inducing positive affect. Additionally, it may be caused by an inappropriate experimental parameter, meaning that the rewards in the motivation group are too large compared with the affect manipulation.

EXPERIMENT 2

Experiment 1 demonstrated that both motivation and positive affect could alleviate ego depletion; however, the working mechanisms of these methods remain unknown. Experiment 2 sought to explore their respective mechanisms. Based on the procedure of Experiment 1, Experiment 2 added an additional dumbbell task as the future self-regulation task. If extrinsic motivation helps to release (not increase) remaining self-regulatory strength, the performance of the motivation group on the future dumbbell task will be worse than the depletion control group because the current dumbbell task performed immediately after the motivation manipulation consumes more remaining self-regulatory resources. Accordingly, if positive affect increases self-regulatory strength, participants in the positive affect group may not perform worse than those in the depletion control group on the future dumbbell task because extra resources were built by positive affect.

Method

Participants

Sixty-seven college students (40 females; $M_{age} = 22.48 \pm 1.95$; all were right

handed) were recruited from three large public universities in a metropolitan area in China and were informed that they would receive 30 RMB for their participation in the study. They were randomly assigned to the motivation group (21 participants), the positive affect group (25 participants) and the depletion control group (21 participants).

Procedure

The materials used in Experiment 2 were similar to those used in Experiment 1, although a few modifications were made. To address the significant differences in DB_2 between the motivation group and the positive affect group in Experiment 1, the rule of cash rewards was changed. In Experiment 2, participants in the motivation group were given 1 RMB for every 20 seconds they held the dumbbell. Additionally, a different comedy video was clipped from the Jimmy Kimmel talk show with Chinese subtitles.

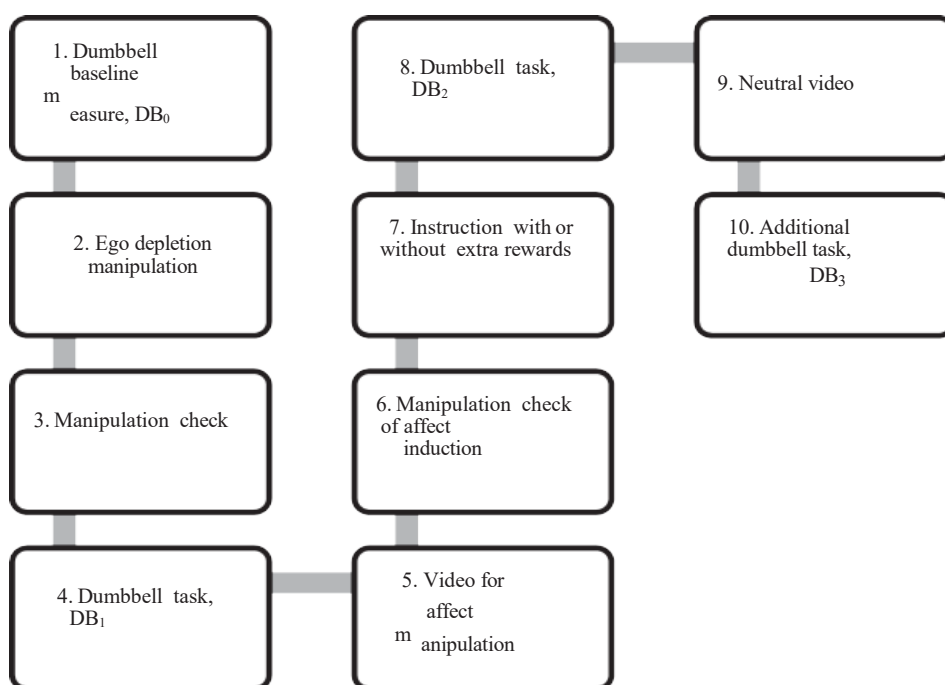


Figure 2. Process of Experiment 2.

Experiment 2 first included the same procedure as Experiment 1. After DB_2 , the participants were instructed to watch a 3-minute video (see step 9 in Figure 2), a landscape documentary clipped from “Wild China,” to help participants reach a neutral-

affect state. Then, the participants were instructed to complete an unexpected dumbbell task (see step 10 in Figure 2). As for the motivation group, the participants were informed that there was no extra reward for this dumbbell task (DB₃). The entire process of Experiment 2 is shown in Figure 2.

Results and discussion

Baseline test and manipulation checks

The three groups showed no significant differences in baseline physical strength, DB₀, $F(2, 64) = 1.92$, $MSE = 2523.46$, ns., and self-regulatory resources after depletion, DB₁, $F(2, 64) = 0.35$, $MSE = 1165.30$, ns., nor did the manipulation check of ego depletion or the PANAS show any significant differences (see Table 2), which suggests that all groups held the same degree of ego depletion and affect state before the manipulation.

The manipulation check of affect indicated that, compared with the motivation and depletion control groups, the participants who watched the comedy video had more positive affect, $F(2,64) = 19.9$, $MSE = 8.34$, $p < .001$, $partial^2 = .38$; nonetheless, no significant difference was found between the motivation and depletion control groups in terms of affect, which supported the notion that the affect induction was valid.

Descriptive statistics are shown in Table 2.

TABLE 2
Descriptive statistics of Experiment 2

	<i>Motivation group</i> (<i>M</i> ± <i>SD</i>)	<i>Affect group</i> (<i>M</i> ± <i>SD</i>)	<i>Control group</i> (<i>M</i> ± <i>SD</i>)
Manipulation check			
Perceived difficulty	3.24 ± 2.51	3.00 ± 2.58	3.81 ± 1.99
Difficulty compared	5.52 ± 1.75	6.12 ± 2.52	6.43 ± 2.18
Energy remained	6.29 ± 1.93	5.48 ± 2.45	5.19 ± 2.25
Preference	4.62 ± 2.75	4.60 ± 2.35	5.33 ± 2.58
PANAS	11.43 ± 7.40	12.08 ± 7.55	12.43 ± 7.93
Affect manipulation	11.24 ± 3.10	16.04 ± 2.21	11.67 ± 3.35
DB ₀	138.95 ± 57.95	113.20 ± 37.88	137.14 ± 54.72
DB ₁	99.00 ± 47.37	90.72 ± 21.24	93.00 ± 30.72
DB ₂	94.00 ± 35.67	84.68 ± 18.02	80.38 ± 24.78
DB ₃	71.76 ± 25.52	78.80 ± 19.21	61.38 ± 13.62

Note: DB₃ indicates the additional dumbbell test.

Dependent measure

To replicate the results of Experiment 1, the same analysis was conducted as in Experiment 1. The results again showed that after the manipulation, the motivation group and the positive affect group performed better than the depletion control group on the current dumbbell task, $F(2, 62) = 3.87$, $MSE = 143.42$, $p < .05$, $partial \eta^2 = .11$. In addition, the adapted manipulation material was successful because no significant difference was found on the dumbbell task post-test after the manipulation (DB₂) between the motivation group and the positive affect group, meaning that extrinsic motivation and positive affect have the same effect on the current task.

ANCOVA of the additional dumbbell task (DB₃) was conducted with the group as the independent variable and DB₀, DB₁ and DB₂ as covariates for the same non-functional reason as in Experiment 1. The results showed that the motivation group and the positive affect group showed different tendencies on the future additional task, $F(2, 61) = 12.16$, $MSE = 123.34$, $p < .001$, $partial \eta^2 = .29$. A *post-hoc* test revealed that the positive affect group performed much better than the depletion control group; however, no significant difference was found between the motivation group and the depletion control group.

The results of Experiment 2 replicated those of Experiment 1 and supported the validity of extrinsic motivation and positive affect in alleviating ego depletion. By

presenting participants with an unexpected additional self-regulation task, Experiment 2 explored the working mechanisms of motivation and positive affect on ego depletion alleviation. If motivation could release remaining self-regulatory resources, the motivation group would perform better on the current task and worse on the future task than the depletion control group. However, no significant difference was found between the motivation and depletion control groups on the future self-regulation task (DB₃). Hypothesis 3 was therefore not supported in this study. Great caution should be used when interpreting the results of this study. It may not be contradictory to the results that a release mechanism was at work for the group that was extrinsically motivated, as some other variables may counteract the release effect of motivation. Hypothesis 4 was supported. We found that the positive affect group performed better than the depletion control group on both DB₂ and DB₃, which indicates a relative increase of the total available resources. Therefore, the results of Experiment 2 revealed that positive affect alleviated ego depletion through the replenishment of self-regulatory resources.

GENERAL DISCUSSION

In accordance with previous studies (i.e. Muraven & Slessareva, 2003), Experiment 1 showed that motivation was an effective way to alleviate ego depletion. The results of Experiment 2, however, did not support the release mechanism of motivation. One possible explanation is that the monetary award might induce positive affect. Some studies have shown that providing participants with surprise rewards can elicit positive affect (e.g. Tice et al., 2007). When participants were informed that they would receive extra money on the next self-regulation task, it was possible that they would have greater positive affect. If so, the release mechanism of motivation may be neutralised by the accompanying replenishment effect of positive affect. However, affect after the motivation manipulation was not measured in this study and should be considered in the future. To summarise, we cannot conclusively deny the release mechanism of motivation within the framework of the strength model. Another possible explanation relies on the process model of ego depletion, which claims that the ego-depletion effect may result from a reduction in motivation for self-regulation rather than the depletion of self-regulatory resources (Inzlicht &

Schmeichel, 2012). In line with the process model, the motivation group participants performed better than the depletion control group participants on DB₂ due to the motivation of a promised reward, but did not outperform depletion participants on DB₃ because the motivational incentive was no longer present. If future studies could control affect and other confounding variables and yield the same results, it would provide evidence for the process model.

Experiment 1 also showed that positive affect was an effective method to alleviate ego depletion, as found in previous studies (i.e. Tice et al., 2007). In Experiment 2, the positive affect group performed better than the depletion control group on the “current” self-regulation task and the additional “future” self-regulation task, indicating an increase or replenishment of self-regulatory resources. Thus, this result supported and extended the Broaden-and-Build Theory (Fredrickson, 1998) in the area of self-regulation. That is, positive affect may also help the body increase self-regulatory resources. Moreover, the replenishment mechanism shed some light on interventions of ego depletion. We could combine multiple methods to amplify the effects of ego-depletion alleviation if such methods could collectively replenish self-regulatory resources. This type of combination is essential, especially when successive self-regulation tasks are included.

It is tempting to interpret the findings on positive affect as indicating that positive affect is essentially the same as self-regulatory resources, but we feel this would be a misinterpretation. The analogy to sleep or rest is illuminating. Sleep or rest can help individuals recover from fatigue and energise them with strength or resources, but sleep itself is not a type of resource. Similar to sleep or rest, we suggest that positive affect is not equal to self-regulatory resources. Future empirical studies can further examine the internal relationship between positive affect and self-regulation.

There are some limitations in this study and many unknowns in the area of ego-depletion research for future studies to address. First, future research could explore release mechanisms of motivation under different experimental conditions such as the use of different rules of rewards or other methods without inducing positive affect. Future research could also explore varying ways to manipulate motivation in general or intrinsic motivation specifically. Second, because the mediating role of positive affect on

the relationship between motivation and self-regulation is unknown, future research could monitor affect change during self-regulation tasks to explore the mediating role of positive affect. Third, it is unknown whether the effects of motivation and positive affect are independent of ego depletion due to the lack of a non-depletion group. For example, if motivation and positive affect also improve performance for individuals at full strength of self-regulatory resources in the non-depletion group, the present results might have less to do with self-regulatory resources. Thus, it is necessary to include a non-depletion group in future studies. Fourth, given the small sample size of this study, future research would benefit from including more participants in each condition to acquire sufficient power. Fifth, different tasks and measurements should be adopted for cross validation. Sixth, the use of three or more self-regulation tasks may provide a new way to explore a wider spectrum of ego depletion.

CONCLUSION

This study showed that ego-depleted participants with extrinsic motivation and positive affect performed better on subsequent self-regulation tasks than depletion control group participants. A replenishment mechanism was found in the positive affect group, thereby alleviating ego depletion. Because of the gradually decreasing performance on the successive dumbbell tasks, the strength model was also supported. Knowing the mechanisms that underlie these effects can help us to better understand both ego depletion and its alleviation, and can contribute to the development of valid intervention programmes.

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